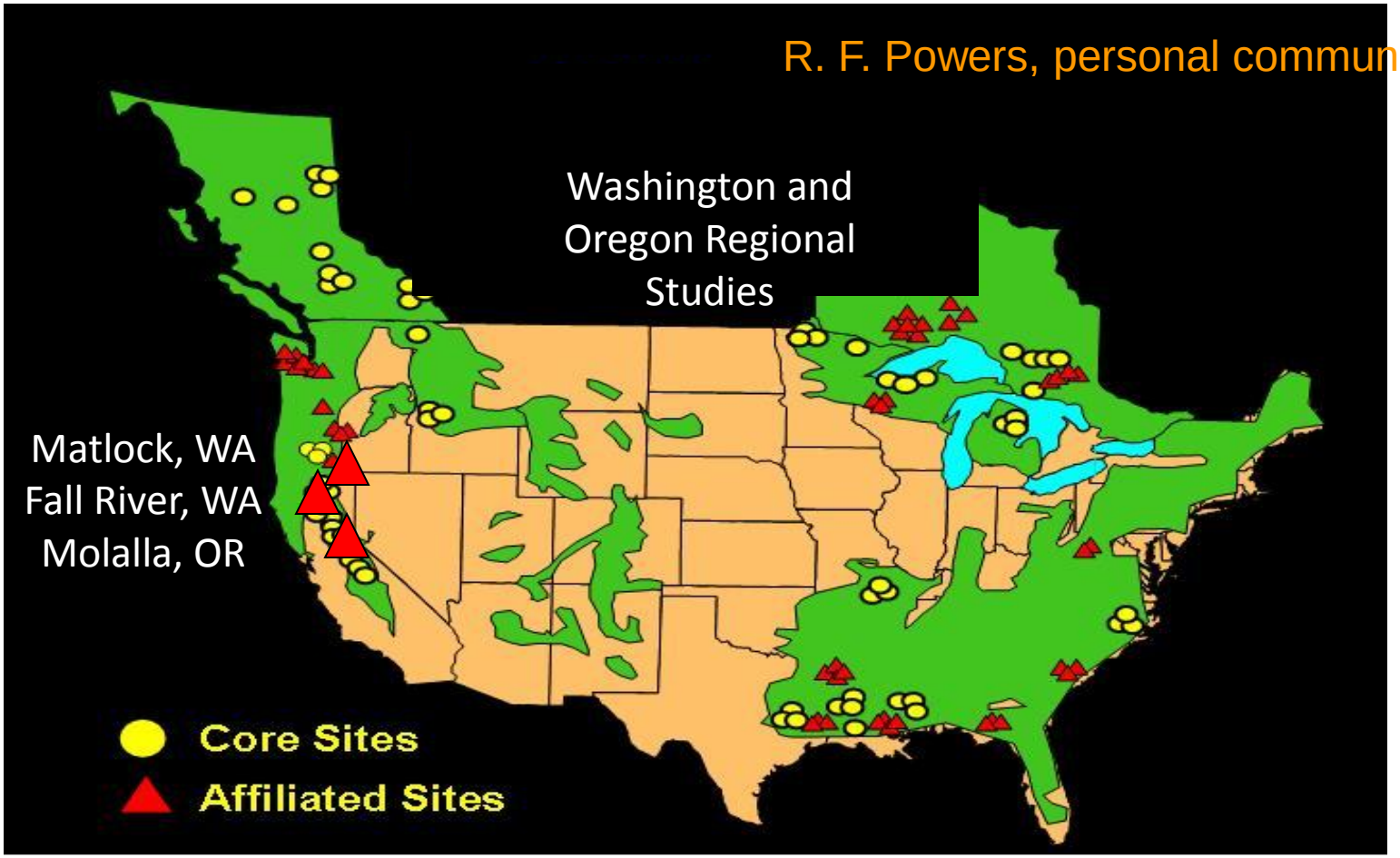
Best Management Practices for Harvest Residuals Management

- Background on Long-term productivity studies
- Key findings
- Managing risk
- Developing site specific BMPs
- Managing soil disturbance

National Long-term Soil Productivity Studies Background:

- **Needed long-term studies to access effects of practices on soil productivity**
- **Study treatments were based on a literature review (Powers and others)**
  - **Two ecosystem properties—organic matter and soil porosity—were most apt to be influenced by management, and have subsequent long-term impacts on soil productivity**
  - **Vegetation control added as an additional treatment to reduce confounding effects**

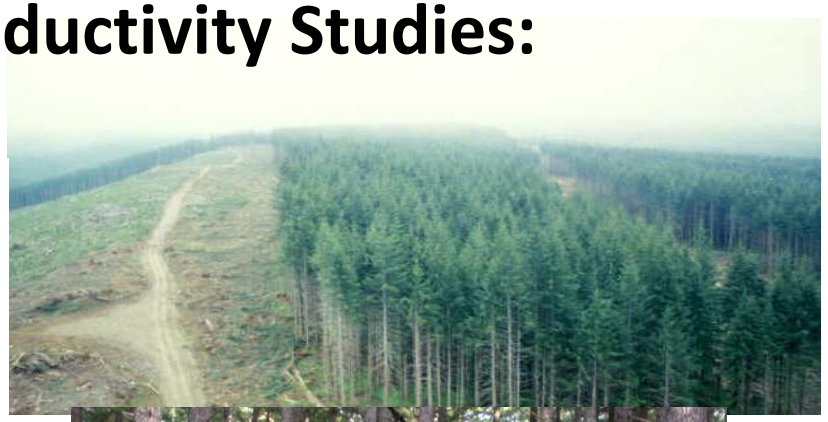
Long-Term Soil Productivity Network



Includes more than 62 sites on major soil and forest types in the United States and Canada. These studies looked at the effects of biomass removal, soil compaction and vegetation control on forest productivity

Regional Long-term Soil Productivity Studies:

Initial Stand Conditions:



Fall River, WA: Planted, age 47 (seed) Douglas-fir / natural hemlock stand; Site Index of 41- to 43-m (135-140 ft)*

Molalla, OR: Natural stand, age 56, Douglas-fir; Site Index 36-m (118 ft.)*

Matlock, WA: Natural stand, age 45, Douglas-fir; Site Index 36-m (118 ft.)*

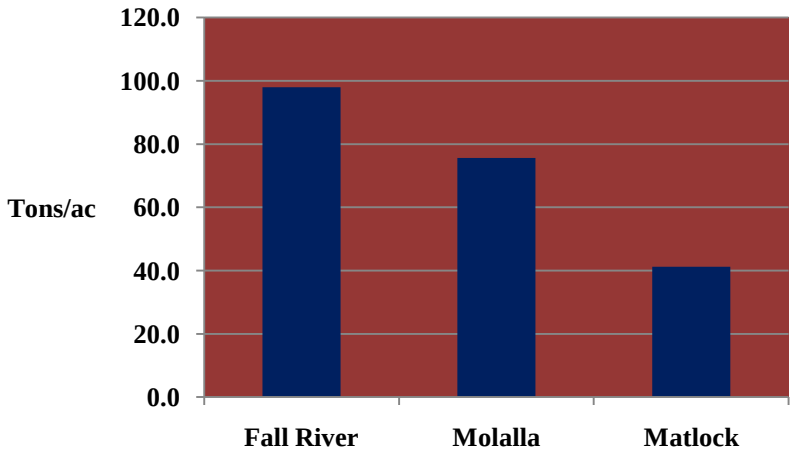
(*Site Index after King 1966)

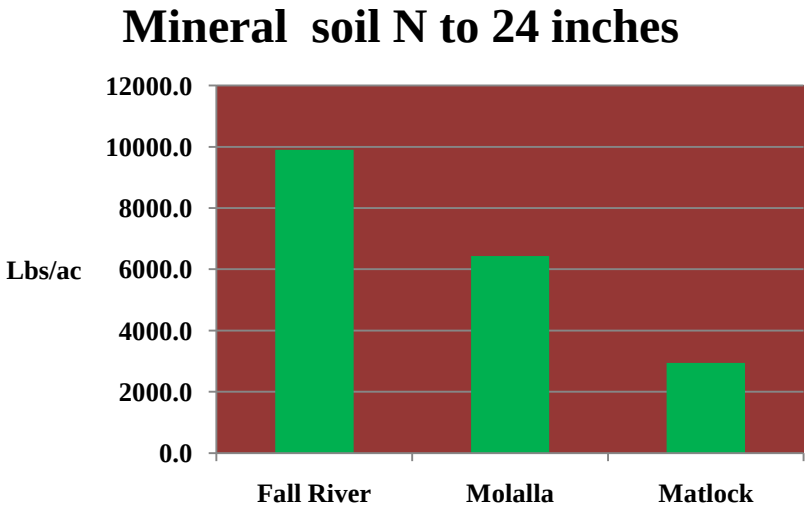
Regional Long-term Site Productivity Studies

Mineral Soil Carbon and Nitrogen to 24 in. depth:

Boistfort

Fall River, WA

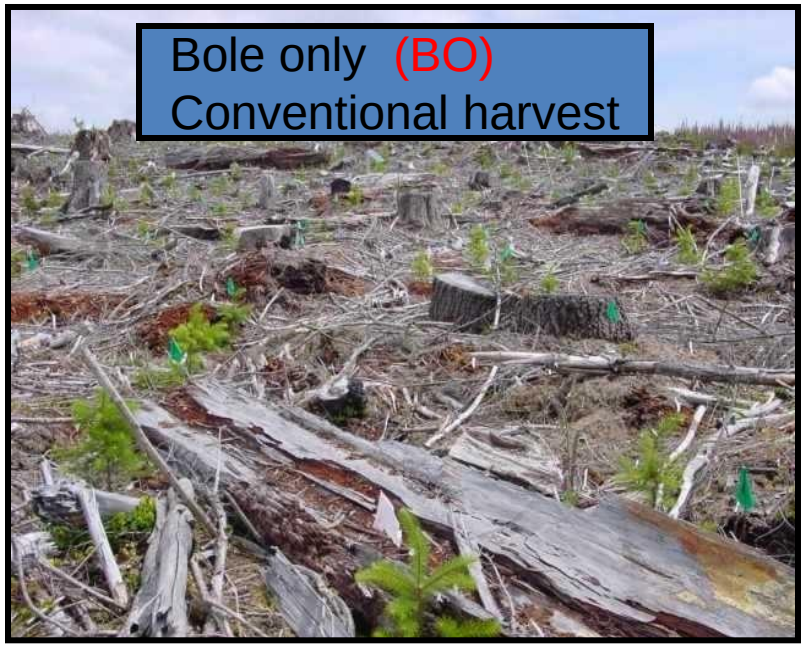


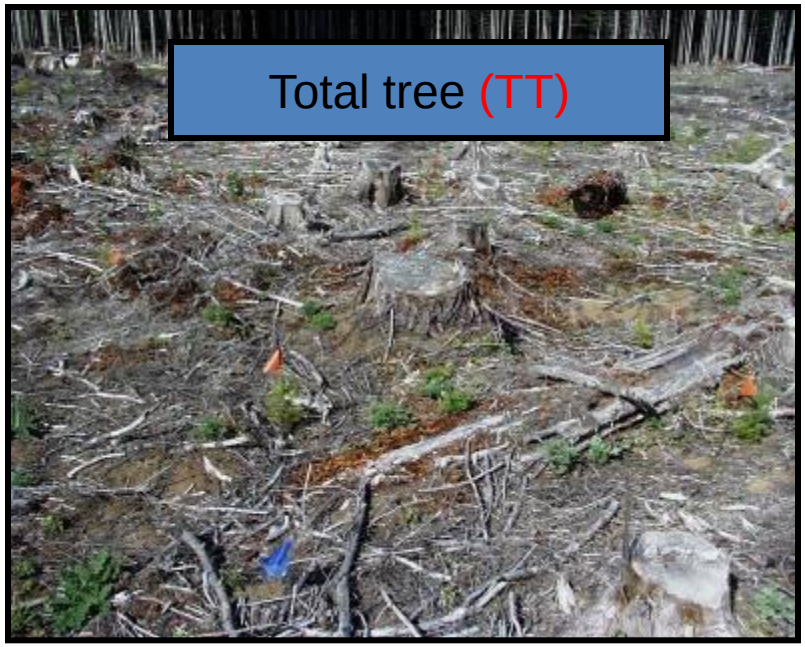


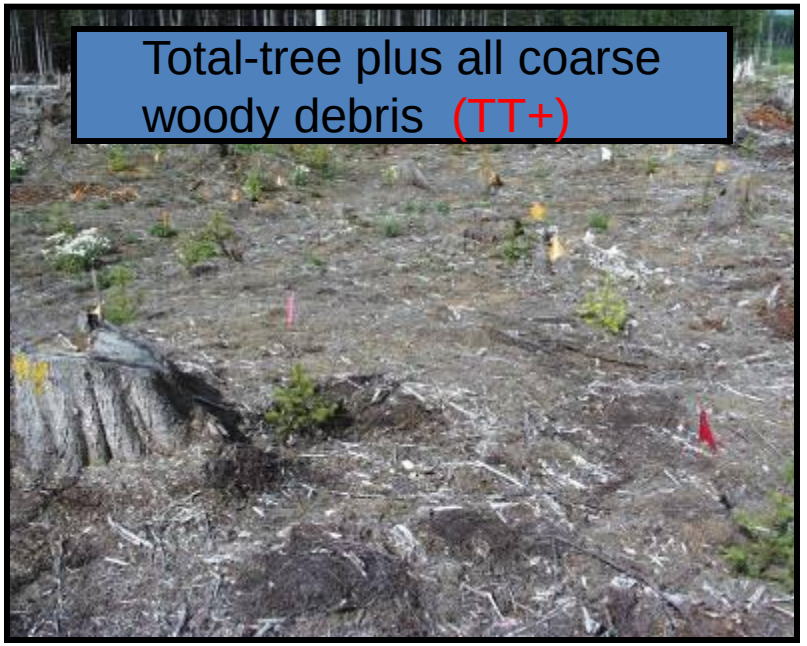
Grove

Matlock, WA

Biomass Removal Treatments: Fall River







Fall River Post-harvest Biomass Residuals Mg/ha (tons/acre)				
	BO	BO5	TT	TT+
Coarse woody debris	60 (27)	37 (16.5)	20 (9)	2 (0.9)
Old-growth stumps	35 (16)	29 (13)	30 (13)	47 (21)
Old-growth logs	70 (31)	76 (34)	28 (12)	0 (0)
Recent stumps	5 (2)	5 (2)	5 (2)	5 (2)

Matlock Post-harvest Biomass Residuals Mg/ha (tons/acre)			
	BO	BO Piled (between piles)	TT
Coarse woody debris	17.4 (7.7)	10.2 (4.5)	9.9 (4.4)
Molalla Post-harvest Biomass Residuals			
Coarse woody debris	16.1 (7.2)	10.4 (4.6)	10.4 (4.6)

After Harrington and Schoenholtz. 2010. Can. J. For. Res. 40: 500-510

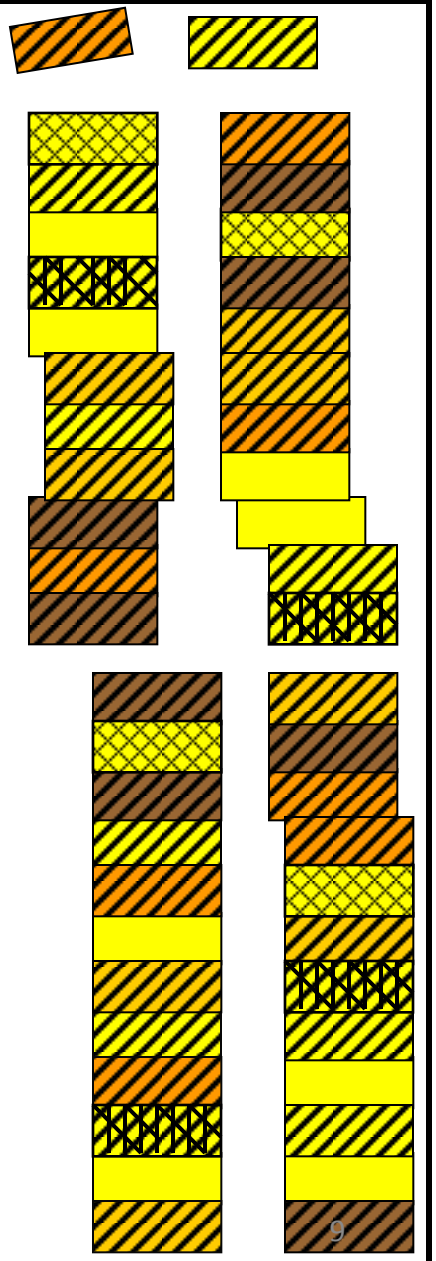
Fall River Study Layout

(4 blocks: two replications per block for OM removal and vegt. control treatments)

Biomass rnemoval

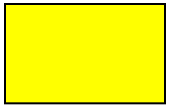
	Bole only	Bole only to 5-cm top	Total tree	Total tree plus
Vegetation control	+	-	+	+	+
Compaction	+				
Compaction & Tillage	+				

+ with vegetation control; - without vegetation control



Molalla / Matlock Studies
(6 treatments x 4 blks or 4 replications)

Biomass removal/manipulation

Vegetation control	Bole only	Bole only mini-pile	Total tree
			
+	-	+	-	+	-

Key Findings

- Biomass removal:
  - Did not significantly affect age-five seedling growth or age 11 tree groth at Fall River
  - Increased removal of biomass increases soil temperature (and reduced seedling growth at age 3 at Fall River…short-term effect)
  - More N in soil solution where biomass maintained (Fall River)
  - Significantly increased Scotch broom at Matlock
  - In national studies growth was reduced on southeast USA sites where forest floor and all above-ground biomass was removed, which had a high percent of P pool. Whole-tree removal generally not significant to date.

- Vegetation management had the main effect on tree growth at all sites
  - Competing vegetation reduced supply of water and nutrients to the seedlings during the growing season plus some shading effect
  - Non-native species (25% of species at Fall River) an issue (grasses, forbs, and Scotch broom)
  - Consistent result across all national LTSP studies

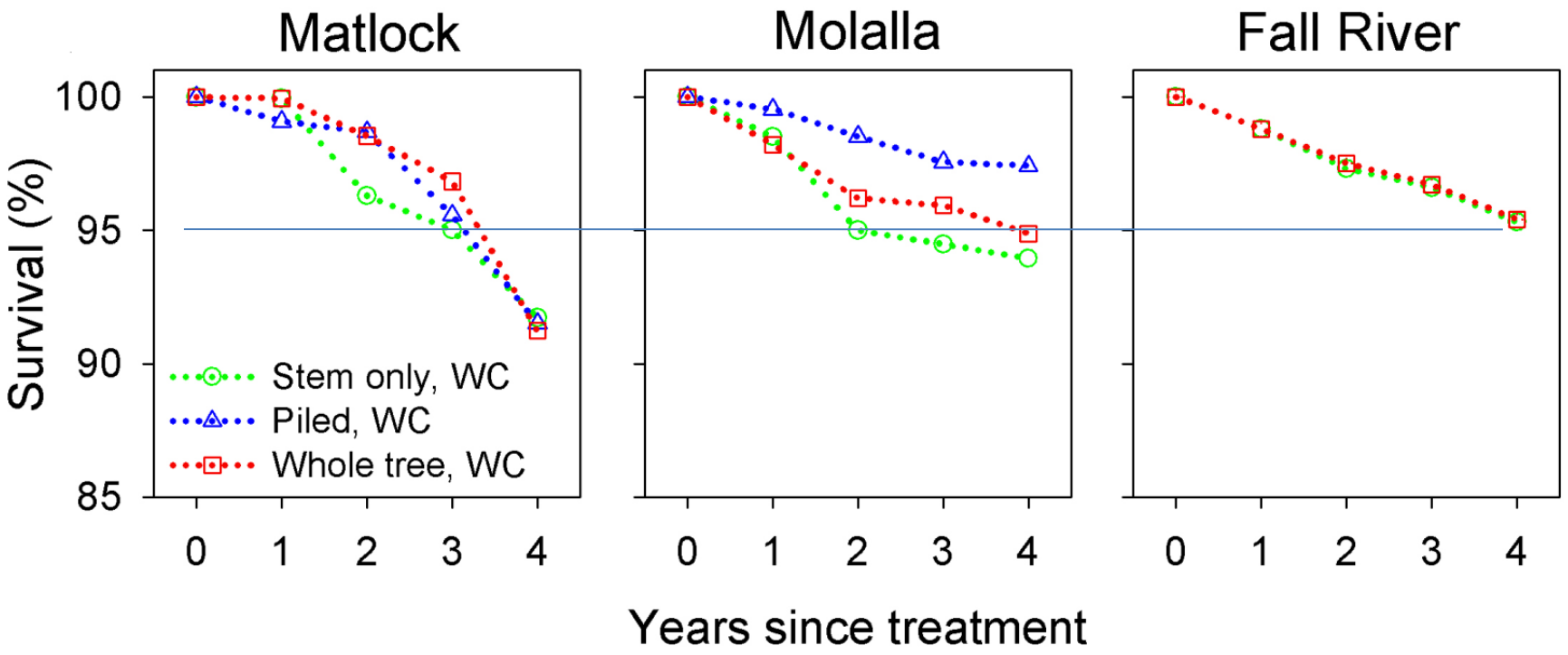
Key Findings

Soil Compaction:

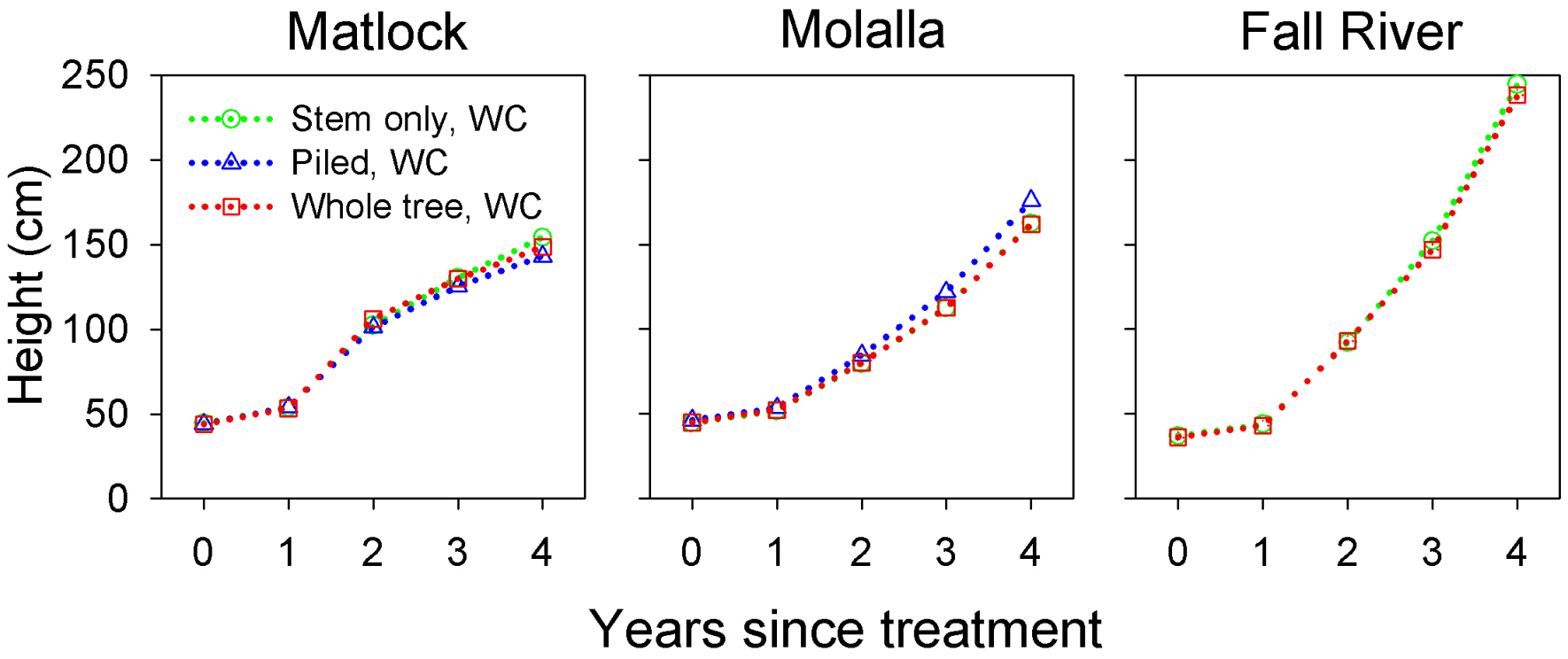
- There was no significant effect from soil compaction on tree growth at Fall River at age five and age 11
  - Trees in the traffic lanes grew better at age three than non-compacted areas due to increased soil moisture holding capacity on the low bulk density Boistfort soil
  - National studies showed either:
    - No effect
    - Positive effect (low bulk density and sandy textured soils)
    - Negative effects (fine textured soils)

  - Generally soil productivity declines have been observed where topsoil is removed or surface drainage is disrupted and soils become saturated.

Seedling Survival by Location and Organic Matter Removal Treatment
Weeded Plots Only

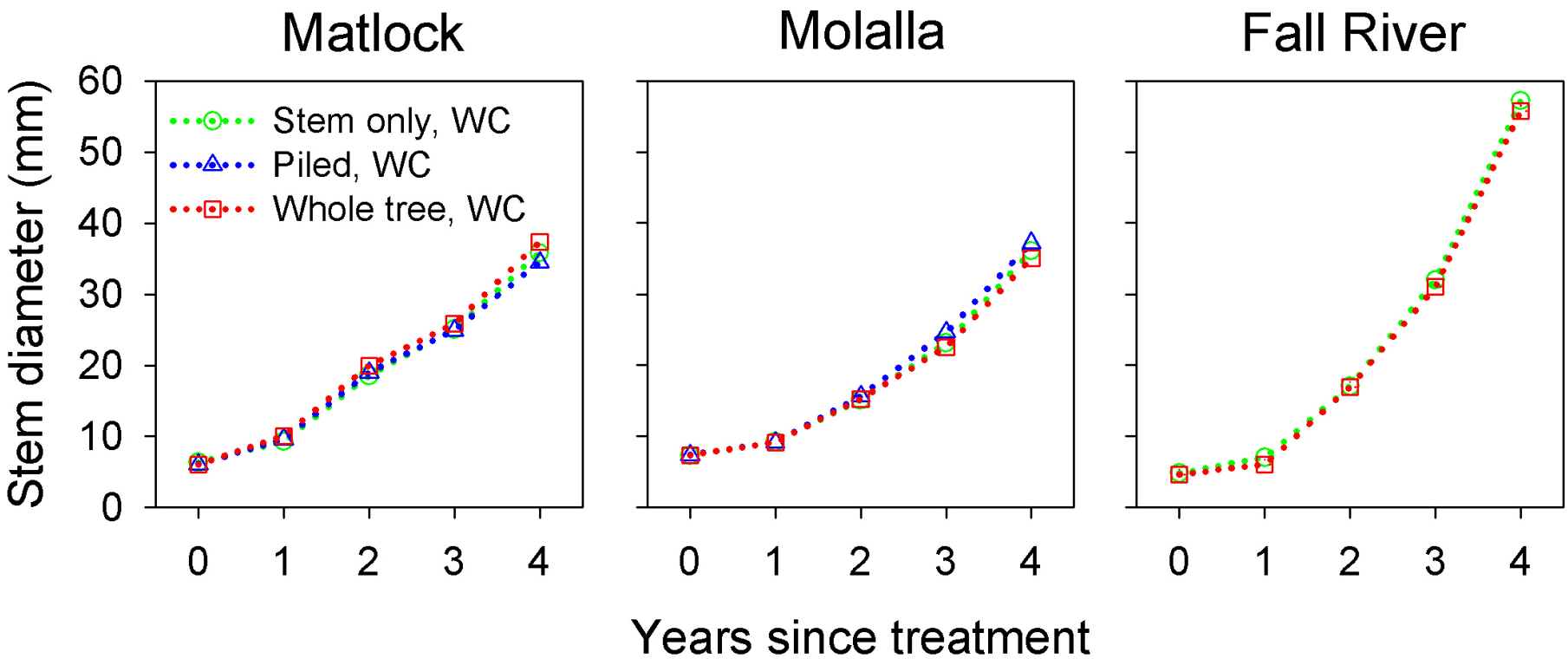


Mean Seedling Heights:
Matlock and Molalla by Year and OM removal Treatment
Weeded treatments only

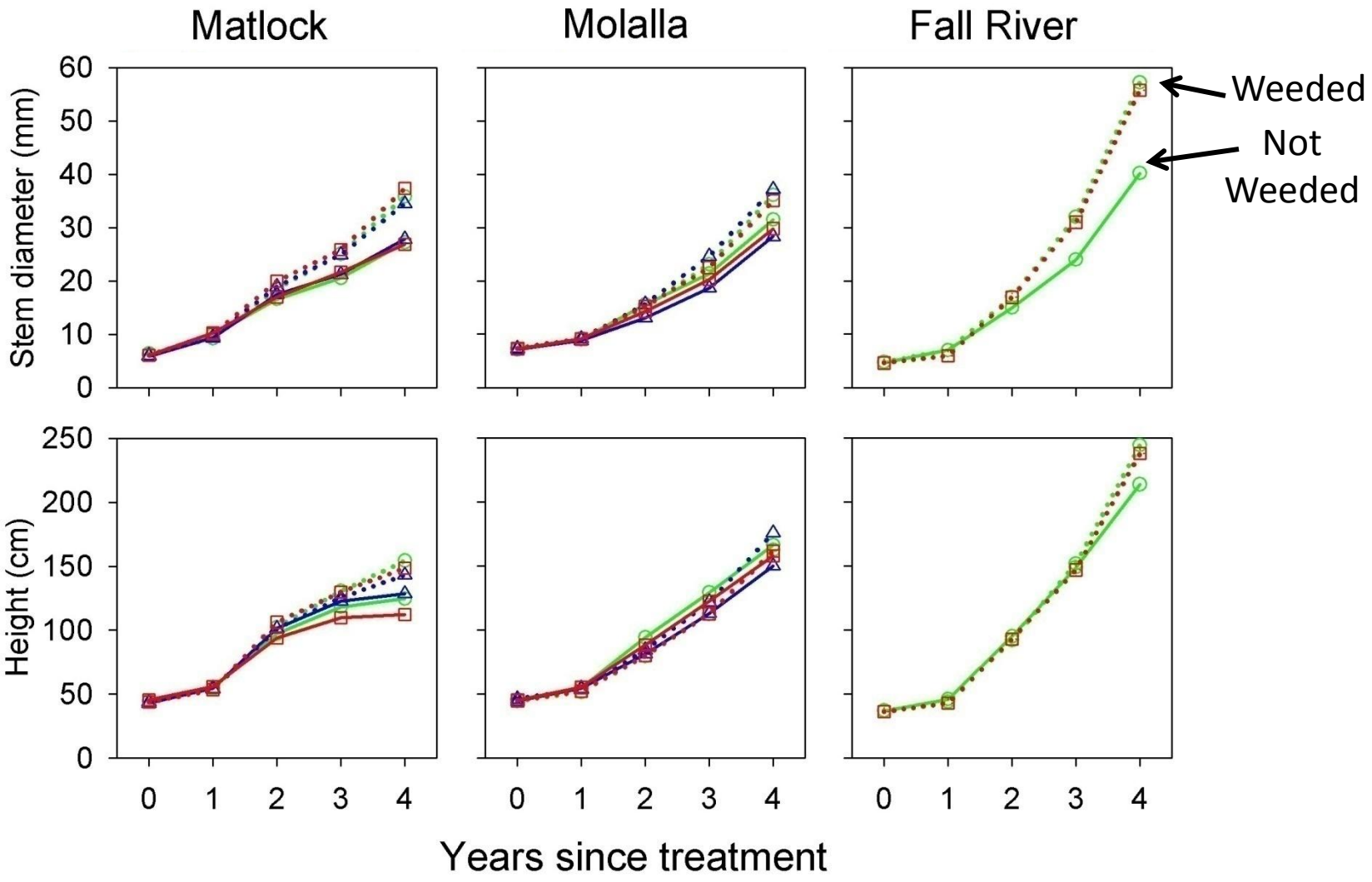


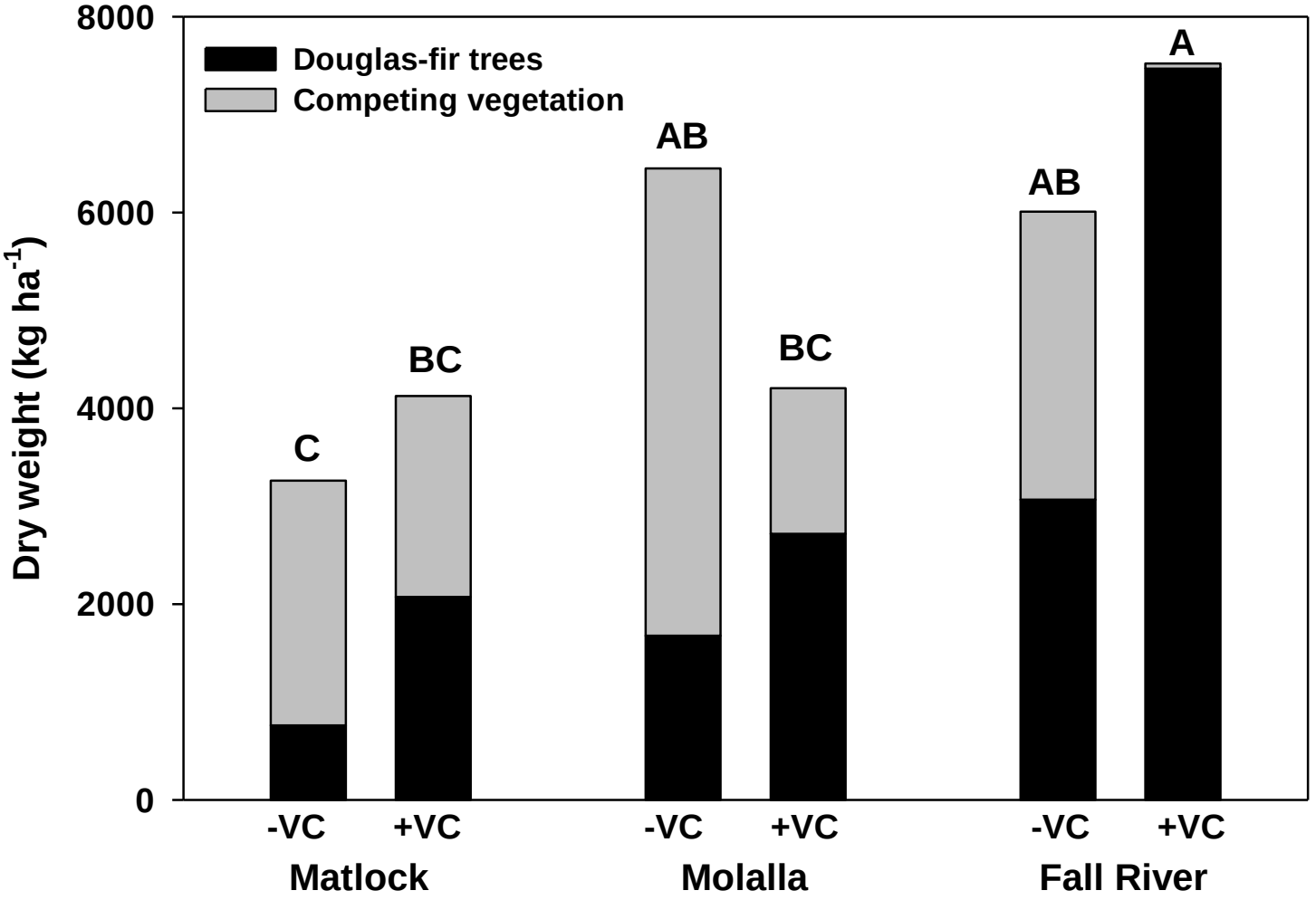
Mean Seedling Caliper (15 cm): Matlock and Molalla by Year and OM Removal Treatment

Weeded treatments only



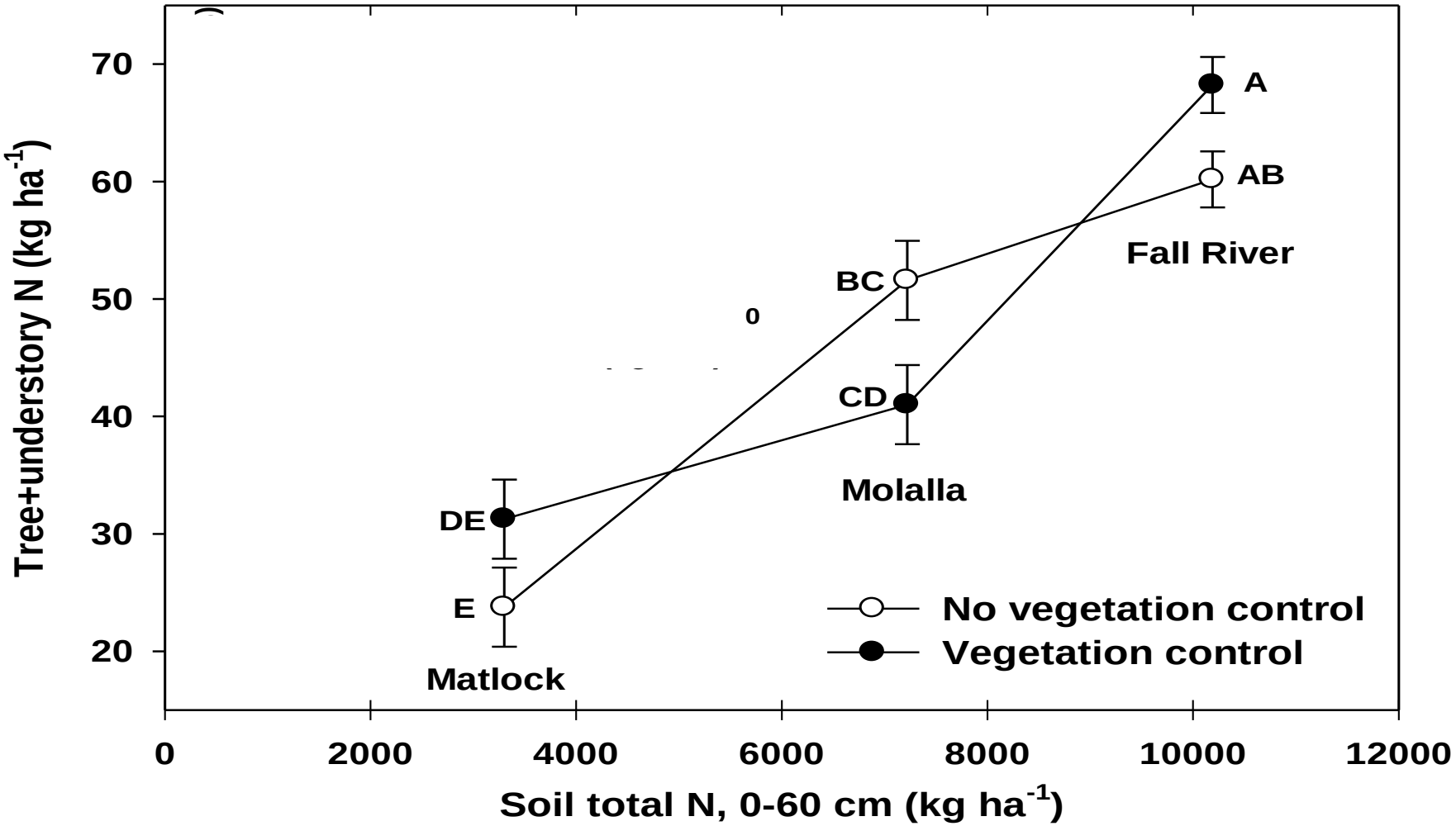
Seedling Mean Diameter and Heights w and w/o Vegetation Control by Location and Organic Removal Treatment





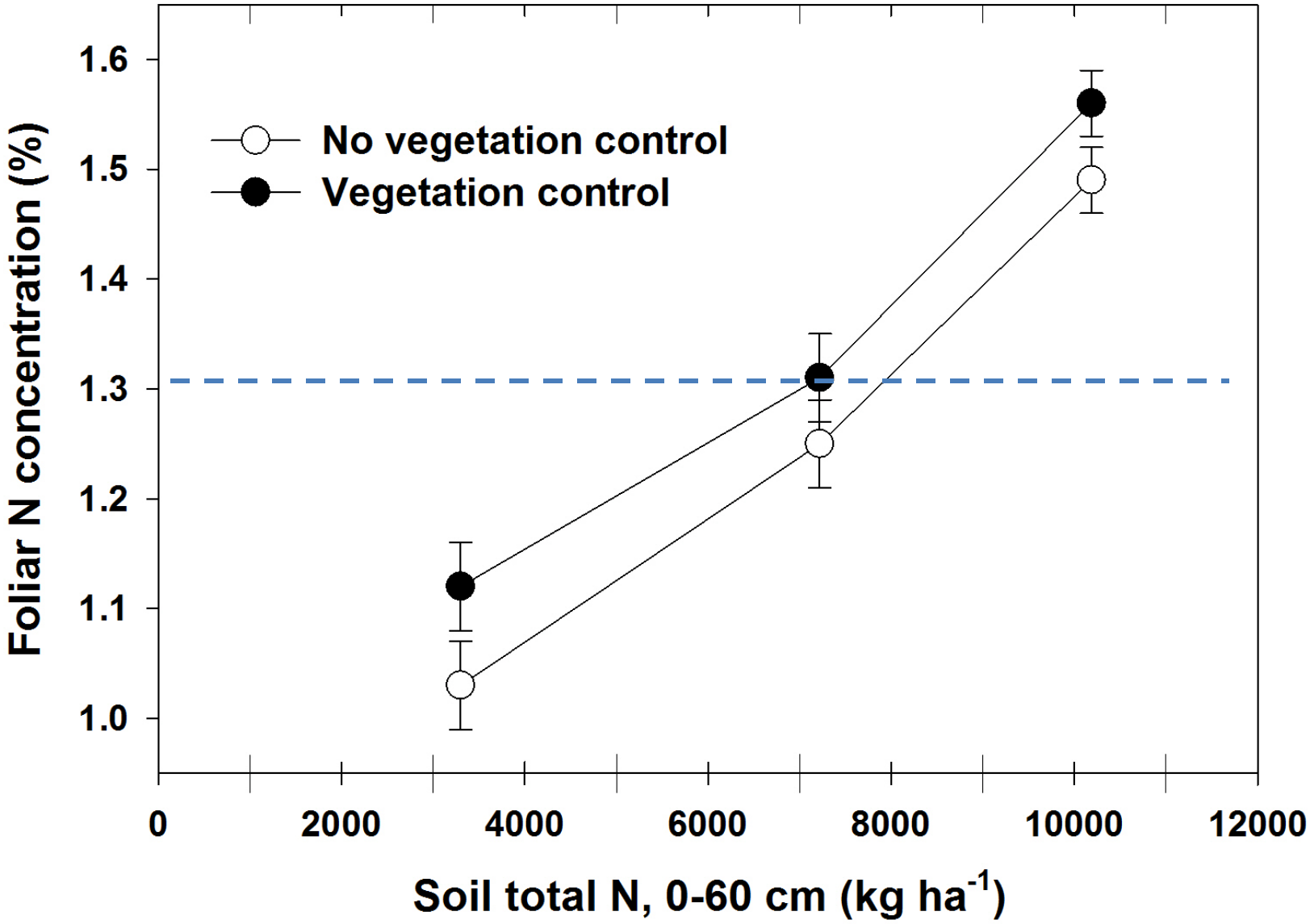
Aboveground dry weight of Douglas-fir trees and competing vegetation, at plantation age five years, without (-VC) and with (+VC) annual vegetation control at three sites. Site/treatment combinations accompanied by the same letter do not differ in total dry weight (trees plus competing vegetation) at $\alpha=0.05$ according to Tukey's test (Sokal and Rohlf 1995).

Tree + Understory N (kg/ha)



Bole-only harvest treatment: Total aboveground nitrogen in living trees and competing vegetation in two vegetation control treatments in five-year-old Douglas-fir plantations on three sites. One standard error is shown. Site/treatment combinations accompanied by the same letter do not differ at α=0.05 according to Tukey's test (Sokal and Rohlf 1995).

Seedling Foliar-N concentration with and without vegetation control across sites



Best management practices (BMPs) for maintaining long-term soil productivity are:

• have a low probability of causing fall-down in soil productive capacity or other detrimental impacts, and have a high likelihood of meeting management objectives

• designed to manage the anticipated risk from a proposed activity at a specific site

  • **risk assessment based on soil nutrient pools, topography, fire hazard, erosion potential, planting capability, etc.**

Potential Hazards + Consequences = RISK

Table 1.2. Example of stressor factors related to harvesting and potential hazards and consequences in a forestry management system.

"Stressor"	**Risk =**	**Potential Hazard**	**+**	**Consequences**
		"Low"	**"High"**	
Harvesting:				
• Equipment		Helicopter	Rubber-tired skidders*	Soil disturbance
• Utilization		Bole-only	Total biomass**	Nutrient removal
				Fuel reduction
				Less debris/"mulch"

* Assumes clay soil logged during the wet season
**Assumes a very nutrient-poor site in this example.

Table 1.3. Example of multiple risks and trade-off considerations on a highly nutrient-deficient site where the consequence of removing high levels of biomass has the potential for negatively impacting soil quality, while reducing wildfire potential.

"Stressor"	**Factor of Concern**		
	Soil Quality (Nutrient pool)	**Fire**	**Weeds**
Utilization level:	----------Potential Risk*----------		
Bole-only	Low	High	Low
Whole-tree	Mod.	Mod.	Mod+
All biomass	High	Low	High

*assumes a low nutrient capitol site with Scotch broom potential

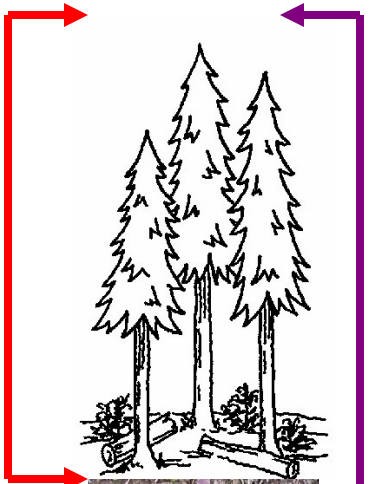
Nitrogen Risk Ratings - Generalized Concept

Proportion of site N pool removed:

Increasing N limitation risk (after Evans, 1999)

Low	Serious	Imminent decline
0.1	0.3	0.5

A =



= T

S =

Nitrogen Risk Ratings - Generalized Concept

Proportion of site N pool removed:

Increasing risk (after Evans, 1999)

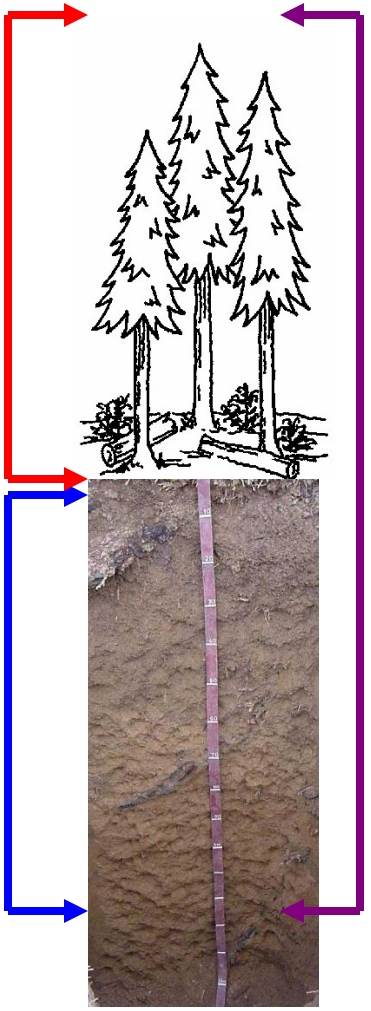
Low	Serious	Imminent decline
0.1	0.3	0.5

A =

Bole-only removal = 0.05 (5%) [Johnson et al. 1982]

Total-tree removal = 0.10 (10%) [Johnson et al. 1982]

S =



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Nitrogen Risk Ratings - Generalized Concept

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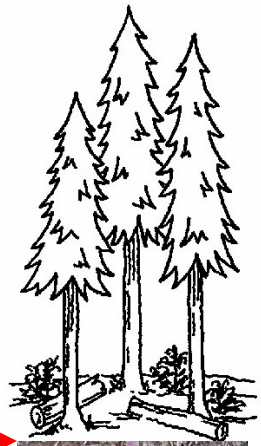
A =



= T

S =

Boistfort soil

Bole-only removal = 0.05 (5%) [Johnson et al. 1982]

Total-tree removal = 0.10 (10%) [Johnson et al. 1982]

Fall River: Total-tree plus forest floor removal = 0.09
(A / T = 1300 kg/ha / 14500 kg/ha = 0.09)

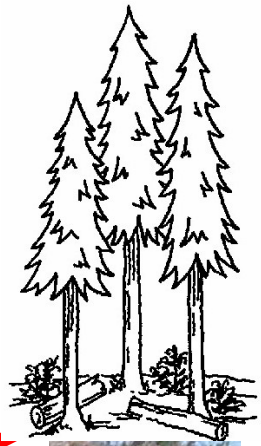
Nitrogen Risk Ratings - Generalized Concept

Proportion of site N pool removed:

Increasing risk (after Evans, 1999)

Low	Serious	Imminent decline
0.1	0.3	0.5

A =



= T

S =

Glacial outwash Grove soil

Bole-only removal = 0.05 (5%) [Johnson et al. 1982]

Total-tree removal = 0.10 (10%)

Fall River : Total-tree plus forest floor = 0.09

Matlock: Total-tree plus forest floor removal = 0.16

Harvest Residuals Management

	Low-Risk Site	High-Risk Site
Forest floor	Retain	Retain
Legacy wood	Retain	Retain
Wood	Meet FP regulations for large woody debris	Meet FP regulations for large woody debris
Fine slash and needles	Conserve, e.g., pile thick slash after needle fall; “total-tree” harvesting is less of a concern	Retain in place / Bole-only harvest; cut-to-length thinning with slash in place
Debris concentrations at landings	Utilize wood but retain fine slash covering after needle fall and retain and scatter legacy wood	Utilize wood but retain fine slash covering after needle fall and retain and scatter legacy wood

Assumes only hazard / consequence is nutrient pool reduction

Forest Practice Regulations

Western Washington			
Wildlife Tree	# per acre	Min. height	Min. diameter
Wildlife Reserve Tree	3	10 ft.	12” DBH (diameter at breast height)
Down log	2	20 ft.	12” DBH at small end
Green Recruitment	1	30 ft. with 1/3 live crown	10” DBH

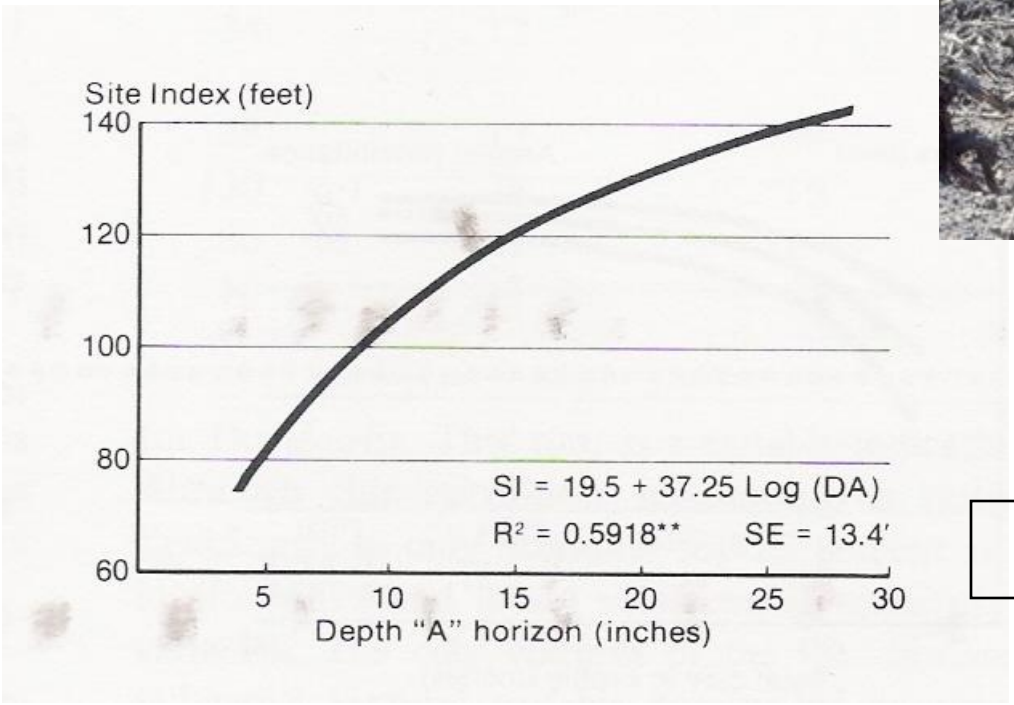
Soil Disturbance: Sustainable Site Productivity

Where losses in forest productivity have occurred there generally has been…

- **Hydrologic function impairment**

– **Topsoil displacement loss – loss of nutrient capital**

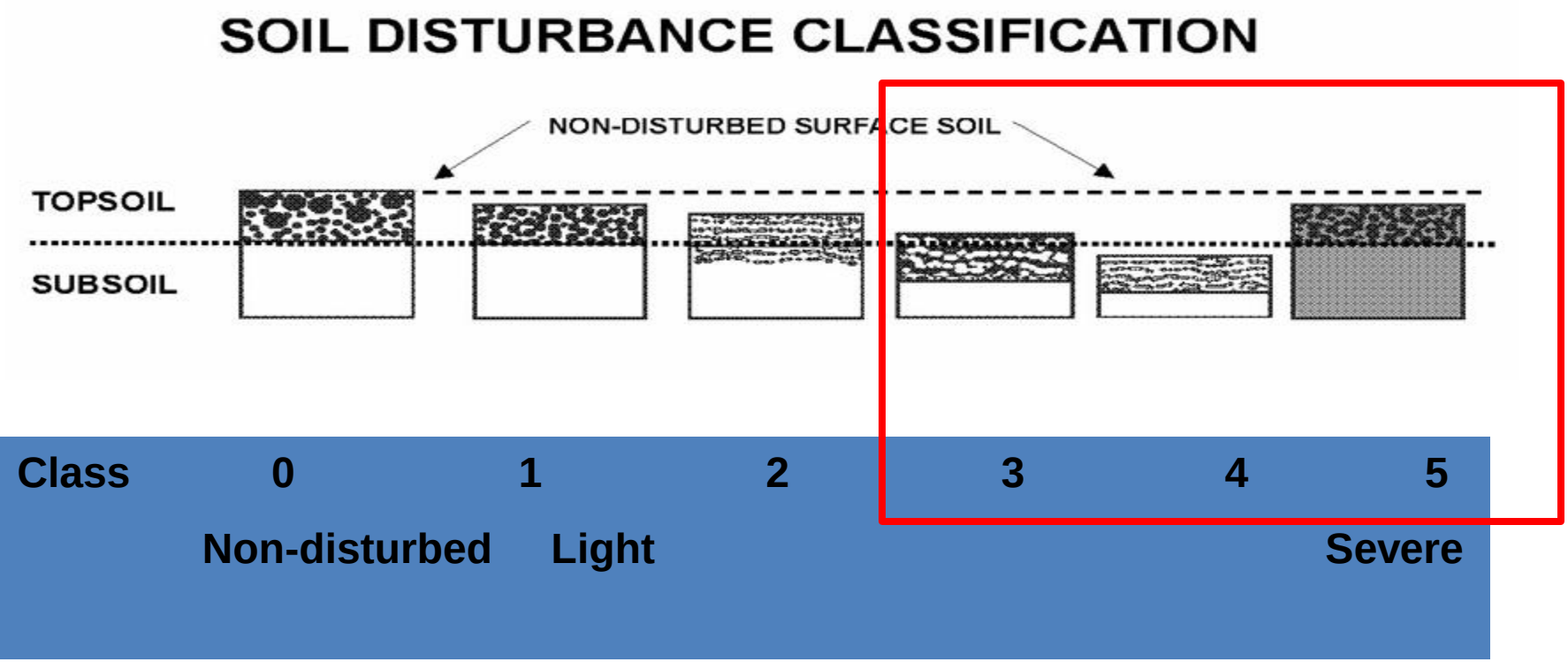
Slash debris piles with topsoil removal



After Steinbrenner, 1979 for residual soils in western WA (Douglas-fir site index)

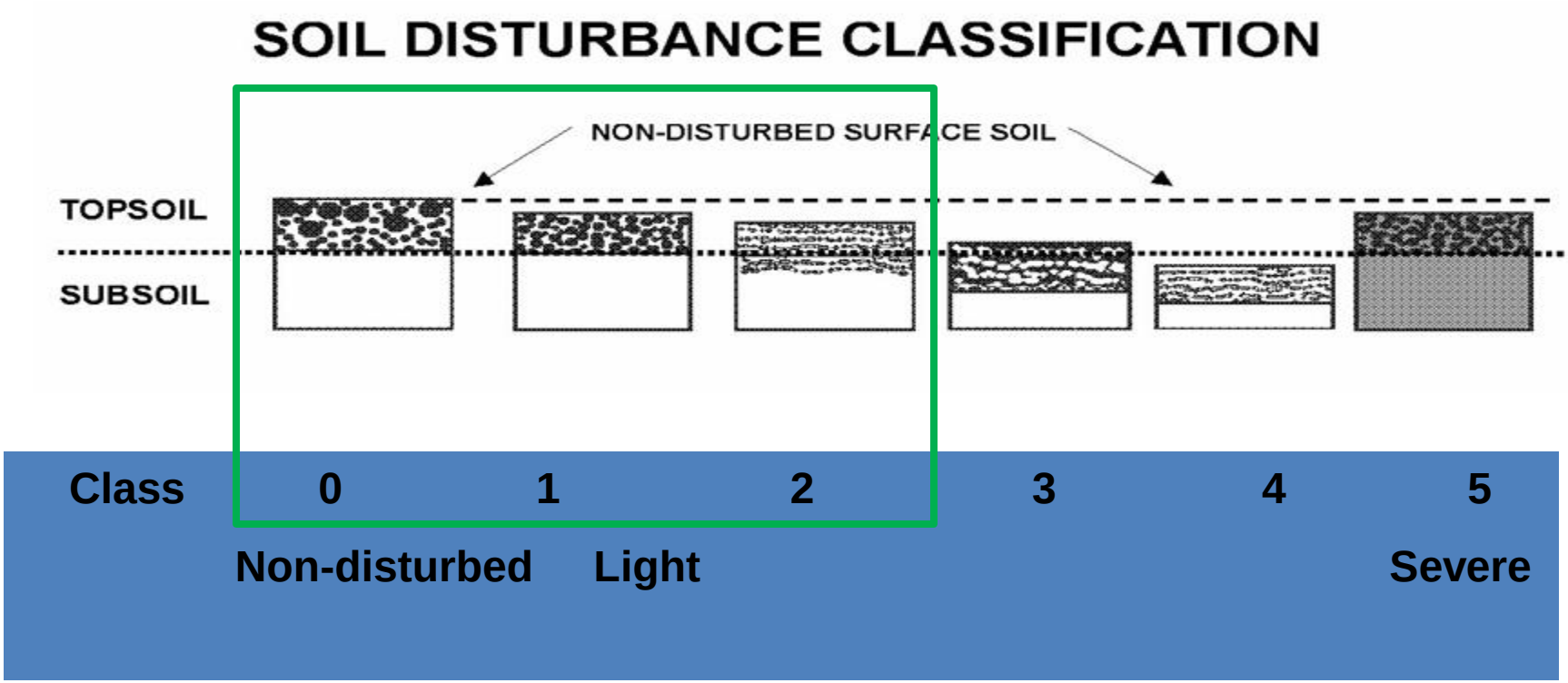
Potential range in soil disturbance

After Scott 2007



Avoid class 3, 4 and 5.

After Scott 2007



Maintain within this range, but limit class 2 on high risk sites

Table 5.1. Example of soil operability risk ratings (after Heninger et.al 2010, page 22) Using these ratings, a soil database spreadsheet based on NRCS modal soil descriptions can be developed.

	Soil Operability Risk Class				
Soil Property	**Low**	**Moderate**	**High**	**Very High**	**Potential for Saturation**
Topsoil Depth	**Very Deep**	**Deep**	**Moderate**	**Shallow**	**Shallow**
Infiltration & Permeability	**Rapid**	**Moderate**	**Slow**	**Very Slow**	**Very Slow**
Texture / Structure	**Sandy / Single grained**	**Loamy**	**Clayey**	**Clayey**	**Clayey / Massive**
Depth to Water Table	**Very Deep**	**Deep**	**Moderate**	**Shallow**	**Very Shallow**